# RESERVE FOOD MATERIALS IN VEGETATIVE TISSUES GWYNETHE M. TUTTLE

In view of the importance of the distribution of starch and fats as food reserve substances in vegetable tissues, and its connection with investigations regarding the effect of low temperatures on cells, it was thought desirable to investigate the conditions prevailing in some trees and shrubs of northern Alberta. Observations by several investigators have been made from other regions in the north temperate belt, such as those of LIDFORSS (3), MIYAKE (4), and SINNOTT (5) from Sweden, Japan, and eastern United States respectively. All of these districts lie between the winter isotherms of 30° and 40° F., whereas northern Alberta lies between those of 10° and 20° F. (1). Furthermore, vegetation in this region is frequently subjected to short periods of very low temperatures during the winter months, reaching  $-50^{\circ}$  F., which makes the problem of resistance to cold a very important one.

LIDFORSS found that all "winter green" leaves are free from starch, but contain sugar and sometimes oil in winter. The

starch is replaced by sugar during November, while the reverse change takes place in April. These results were largely confirmed for this region. Much of the material examined by SINNOTT retained starch as a food reserve throughout the winter, although many of the species were characterized by an oily reserve. He found that starch was most common in regions remote from the conducting channels, and fat most abundant in and near the phloem, close to the vessels. His "starch" trees were characterized by thick, squarish medullary ray cells with strongly lignified and small pitted walls; while the "fat" trees showed medullary ray cells with thin or unlignified walls and large pits. This he interpreted as indicating that "the character of the food reserve in any cell depends primarily upon the ease with which water, or substances carried by water, have access to the cell. Where the movement is apparently slow and difficult, the reserve persists as [146 Botanical Gazette, vol. 71]

### TUTTLE-RESERVE FOOD

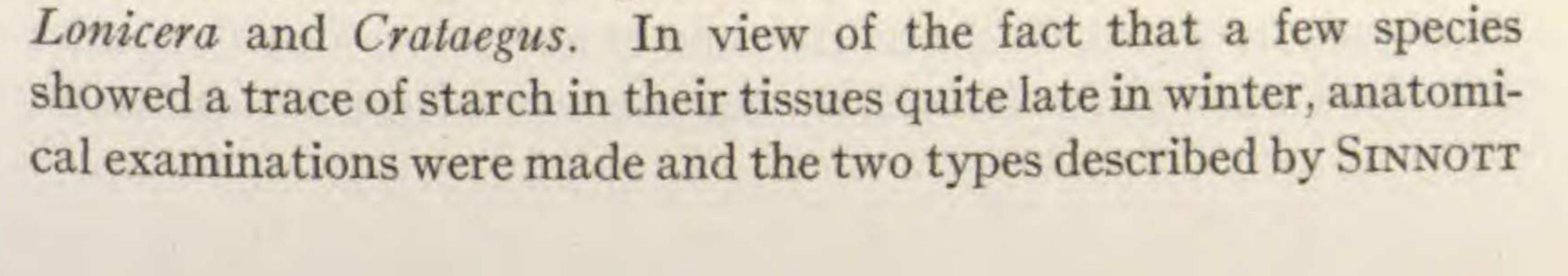
147

1921]

starch; where such movement is easy, starch disappears at the beginning of winter and fat is produced."

A representative number of trees, shrubs, and perennial herbaceous plants of the region round Edmonton were examined. As the number of native plants with "winter green" leaves was very limited, tests of the stems of the deciduous types were included in the observations. Sections of the leaf, stem, and bud were tested with iodine solution and osmic acid at intervals from October to June. Records extending over three seasons show very little variation during October. Starch was quite abundant in the medullary ray cells, phloem, and cortex. Oils and fats were present in nearly all cells of the phloem and cortex and in the medullary ray cells of some plants. In several cases cortical cells contained food reserve which did not react to either iodine or osmic acid, suggesting the "transitory substance" mentioned by SINNOTT. Various tests were applied, but the identity of the substance was not determined. Some of the material was tested microchemically for sugar by means of the Flückiger reaction (6). Heavy precipitates of cuprous oxide were obtained (on heating) in Syringa, Populus, Prunus, Salix, Shepherdia, Ribes, Picea, Pinus, Rosa, Pyrola, Cornus, and Eleagnus, indicating the presence of glucose and dextrins. A positive determination of sugars could not be obtained by this means, on account of the possibility of the presence of a large number of other reducing substances in the cells; and in the absence of a satisfactory microchemical test for sugars, the work was not continued. Quantitative determinations of the sugar contents of a few cell saps made in another investigation have been recorded (2), where it was found that the total sugars varied from 0.5 to 2 per cent. The condition of the starch and oil reserve, tested at different seasons, is shown in table I.

In the majority of cases starch disappeared from the local plants during October and early November. Oils and fats were abundant in all of the species examined, with the exception of



# 148

### BOTANICAL GAZETTE

FEBRUARY

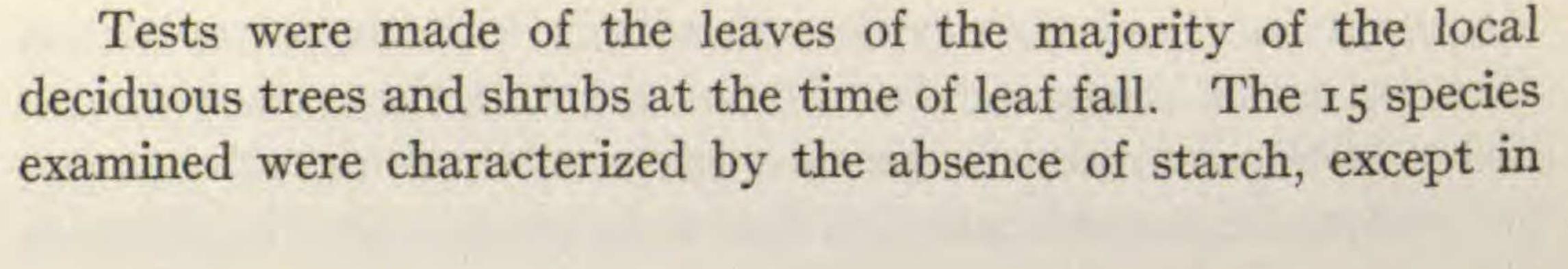
as "fat" and "starch" trees were recognized. Those species which retained small quantities of starch corresponded in all cases to the structure of "starch" trees, whereas those in which conversion was most rapid were of the "fat" tree type. Although species which retained definite starch reserve during the winter are absent from this locality, certain of the facts seemed to give limited support to the

TABLE I

Material	October	December	February	May		
Populus tremuloides	S and O	0	0	S and O		
Populus balsamifera		0	0			
Salix rubra	the second	0	0			
Shepherdia canadense		0	0	S and O		
Betula subcordata			0			
Amelanchier alnifolia				S and O		
Alnus incana			~	S and O		
Pyrola rotundifolia	and a second of a local fragment of the local second of the local	0	Ô	0		
Cornus canadensis		Õ	Õ	0		
Linnaea borealis var. americana.		Ō	Ō	0		
Mitella nuda		Ō	Õ			
Corylus rostrata			Õ	S and O		
Picea canadensis		0	Õ			
Pinus Banksiana		Ō	Õ			
Ledum groenlandicum						
Arctostaphylos Uva-ursi		0	0	S and O		
Vaccinium Vitis-Idaea						
Viburnum pauciflorum		0		S and O		
Prunus pennsylvanica	S and O	Ó	Ó			
Ribes setosum	S and O	SS and O	SS and O	S and O		
Symphoricarpos occidentalis		SS and O	SS and O	S and O		
Rosa arkansana	and the second se	SS and O	SS and O	S and O		
Eleagnus argentea		SS and O	0	S and O		
Cornus stolonifera		SS and O	0	S and O		
Crataegus tomentosa	a second s	SS and O	0	S and O		
Lonicera glaucescens						
Exotic shrubs						
Syringa vulgaris	S and O	SS and O	0	SS and O		
Carragana sp	S	SS	No starch			
Ribes sp	S and O	SS and O	~			
Acer Negundo	the second se	SS and O				

S, starch; SS, slight starch reaction; O, oils and fats.

view recently suggested by SINNOTT in regard to the relation of structure to the nature of food reserve.



#### 1921] TUTTLE-RESERVE FOOD 149

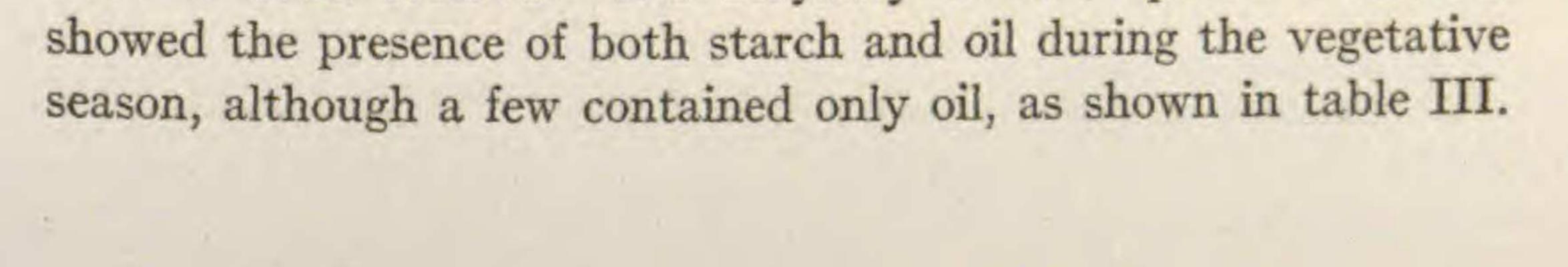
Ribes and Cornus, which were found to contain minute quantities, whereas all showed a relatively high oil and fat content. The winter buds of the same trees showed a high percentage of starch at this time. It would seem that the starch had either been converted in the mature leaves before leaf fall or else translocated to other regions of the plant. Table II records the leaf material tested.

TABLE II

MATERIAL							
Symphoricarpos sp.						. 1	
.Symphoricarpos occid							
Ribes sp							
Ribes setosum .							
Betula subcordata							
Rubus sp							
Corylus rostrata .							
Fragaria sp							
Corydalis sp		4.1					
Ledum groenlandicum	1						
Arctostaphylos Uva-u	ırsi				,		
Vaccinium Vitis-Idaea	a						
Syringa vulgaris .							
Cornus stolonifera						•	

FOOD RESERVE Oils and fats Oils and fats Oils and fats Trace of starch Oils and fats Trace of starch Oils and fats

Several species of Salicaceae and Ericaceae were examined from high elevations in the mountains of Alberta and British Columbia, with a view to determining any difference in food reserve due to the different habitat. Herbarium specimens were used for the tests as fresh material was not obtainable. As these had been quickly and carefully dried, there is no reason to suppose that the starch or fat content of the cells would have been affected. Material of the stem was softened in water and tested immediately. Very definite reactions were obtained. Most of the material had been collected at the height of the vegetative season for the elevations at which it occurred. It was not possible to establish any connection between high elevation and a difference of food reserve. The majority of the species examined



#### 150

#### BOTANICAL GAZETTE

#### [FEBRUARY

#### TABLE III

MATERIAL

ELEVATION IN FT. DATE OF COLLECTION

Starc	h and	oil	present
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Salix glaucops							6000	August 9			
Salix nivalis							7500	July 18			
Salix herbacea							8200	July 23			
Phyllodoce empetriformis							7200	July 12			
Kalmia glauca			-				5000	August 25			
Phyllodoce glanduliflora							7500	July 18			
Arctostaphylos Uva-ursi							5000	July			
Ledum groenlandicum .							5000	July			
Rhododendron albiflorum				+			7500	July 27			
Menziesia glabella							6000	July 3			
							6500	June 26.			
Arctostaphylos alpina .							Lowland	August 4			
Arctostaphylos alpina .							6700	June 25			
Cassiope Mertensiana .							4000	August			
Oils and fats only											
Salix vestita							6400	July 17			
Salix arctica							7100	July 26			
Gaultheria ovatifolia .							Lowland	August 15			
Arctuous erythrocarpa .							5000	August 15			
Empetrum nigrum							5100	August 15			

# Summary

1. All the species examined showed a high starch content during the summer, which disappeared during October.

2. All the trees and shrubs of this district which were examined contained oils and fats as food reserve during winter with the exception of *Lonicera glaucescens* and *Crataegus* sp. The presence of sugar was demonstrated in many of the species. Quantitative determinations in a few places gave a total sugar content of 0.5-2per cent.

3. Deciduous leaves, at the time of leaf fall, were devoid of starch, but contained oils and fats.

4. Most of the species of alpine Salicaceae and Ericaceae examined showed the presence of both starch and oil during the vegetative season. *Gaultheria ovatifolia*, a lowland species, showed only oil. Hence the ability to form starch does not seem to be

# associated with climatic conditions, resulting from high altitudes. UNIVERSITY OF ALBERTA EDMONTON, CANADA

#### 1921]

## TUTTLE-RESERVE FOOD

151

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